A Moored System to Obtain High-Resolution Time Series of Velocity and Density in High Current Environments

Jonathan D. Nash
College of Oceanic & Atmospheric Sciences
Oregon State University
Corvallis OR 97331-5503
ph: (541) 737-4573 fx: (541) 737-2064
email: nash@coas.oregonstate.edu

Award #: N00014-10-1-0701
http://mixing.coas.oregonstate.edu/

LONG-TERM GOALS

We seek a more complete and fundamental understanding of the hierarchy of processes which transfer energy and momentum from large scales, feed the internal wavefield, and ultimately dissipate through turbulence. This cascade impacts the acoustic, optical, and biogeochemical properties of the water column, and feeds back to alter the larger scale circulation. Studies within the **Ocean Mixing Group** at OSU emphasize observations, innovative sensor / instrumentation development and integration, and process-oriented internal wave and turbulence modeling for interpretation.

Fig 1: The 16 foot long stablemoor being deployed in Luzon Strait. This is the backbone of the mooring – with 3 ADCPs, 2 CTDs, a turbulence/motion package and satellite communications. It also provides 2000 lbs of buoyancy, so is a mechanical centerpiece for the mooring as well.

OBJECTIVES

Luzon Strait represents a major source of internal tides and NLIWs in the SCS. However, because of the extreme currents and internal wave activity in the Strait, there has been little success in deploying a full-water column mooring in this region. The goal of this project is to obtain a 2-month timeseries of

Report Documentation Page

Form Approved
OMB No. 0704-0188

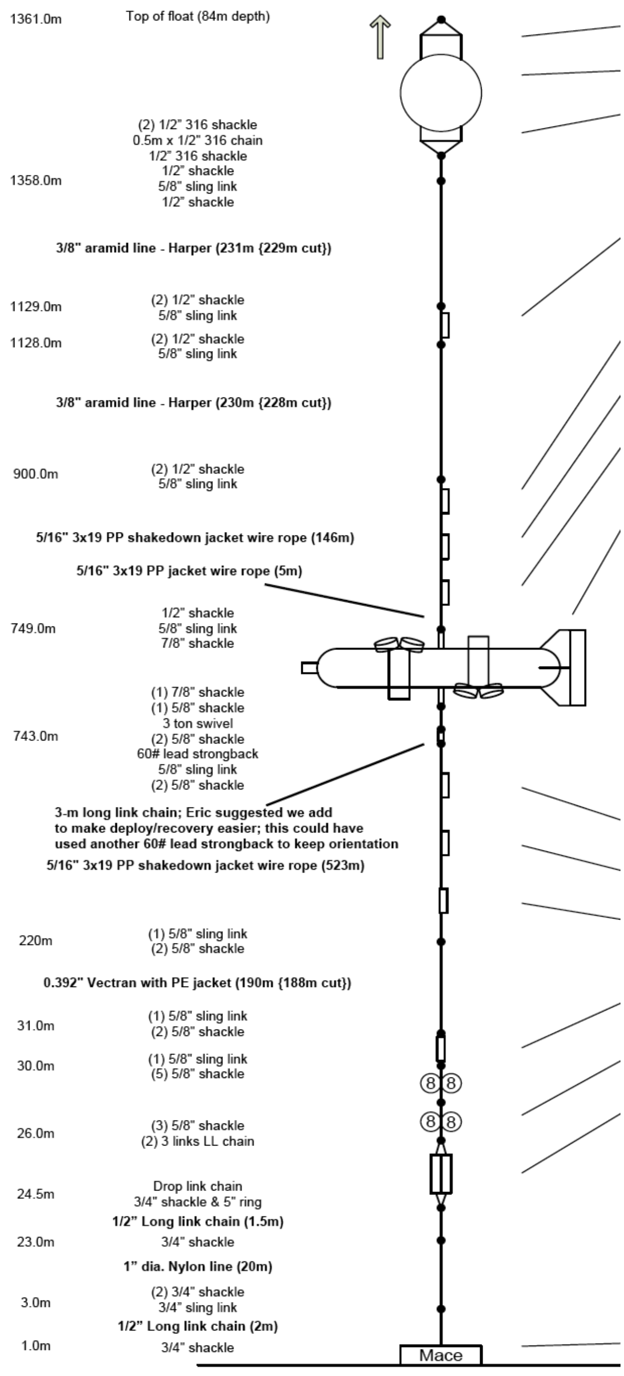
1. REPORT DATE **30 SEP 2011**	2. REPORT TYPE	3. DATES COVERED **00-00-2011 to 00-00-2011**
4. TITLE AND SUBTITLE **A Moored System to Obtain High-Resolution Time Series of Velocity and Density in High Current Environments**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Oregon State University,College of Oceanic & Atmospheric Sciences,Corvallis,OR,97331-5503**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

full watercolumn velocity, density and turbulence in the heart of the Strait where internal tide generation is the most intense. This award funded the fabrication/acquisition of a mooring & components deployed in Luzon Strait to:

- identify hotspots of generation and dissipation,
- quantify the structure and time-variability of wave energy, its flux and dissipation at the generation site.
- link the broader spatial structure, temporal content, and energetics of the internal wave field to the topography, forcing, and mesoscale influences (i.e., Kuroshio).



APPROACH

1. The stablemoor (pictured above) and 4 additional T-chain moorings were successfully deployed and recovered in 2 of the most energetic regions of the strait. Recovery cruises were mid Aug and early Sept, 2011; we have just started the analysis of these data.

WORK COMPLETED

All components of this new mooring were purchased or fabricated. Included on the stablemoor were 2 75 kHz ADCPs (each with 600-700 m range), a 300 kHz ADCP, our in-house fabricated microstructure and motion package (installed in the stablemoor nose), CTD/T-loggers, satellite beacons, flashers etc. Two other turbulence packages were deployed on the mooring wire, along with numerous CTDs, fast-response T-loggers, and an additional ADCP in the surface float. This mooring system thus measures full-water column velocity and density, and also measures temperature microstructure at several discrete locations, permitting dissipation rates of temperature variance (χ) and TKE (ε) to be computed.

Fig 2: The mooring diagram (right) shows mechanical components. More than 40 C/T sensors were deployed along the wire.

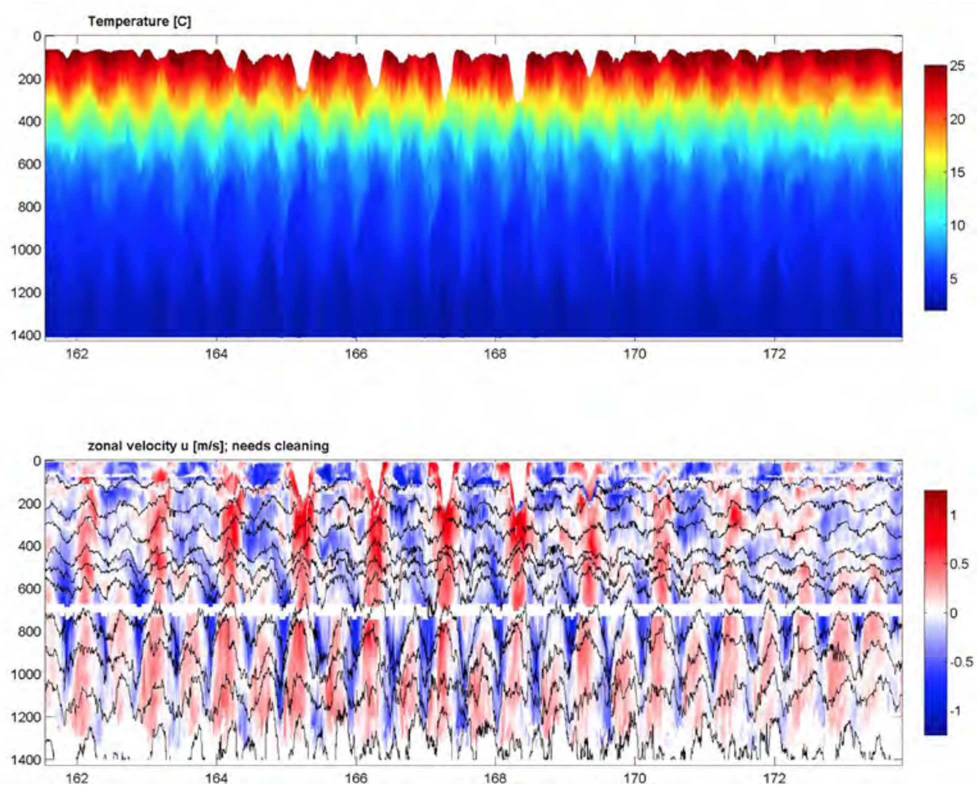


Figure 3: A 12-day record of T (top) and velocity (bottom; with T contoured) from the stablemoor mooring. Time is in yeardays (2011); depth in m. Peak flows and displacements exceed 1 m/s and 300 m.

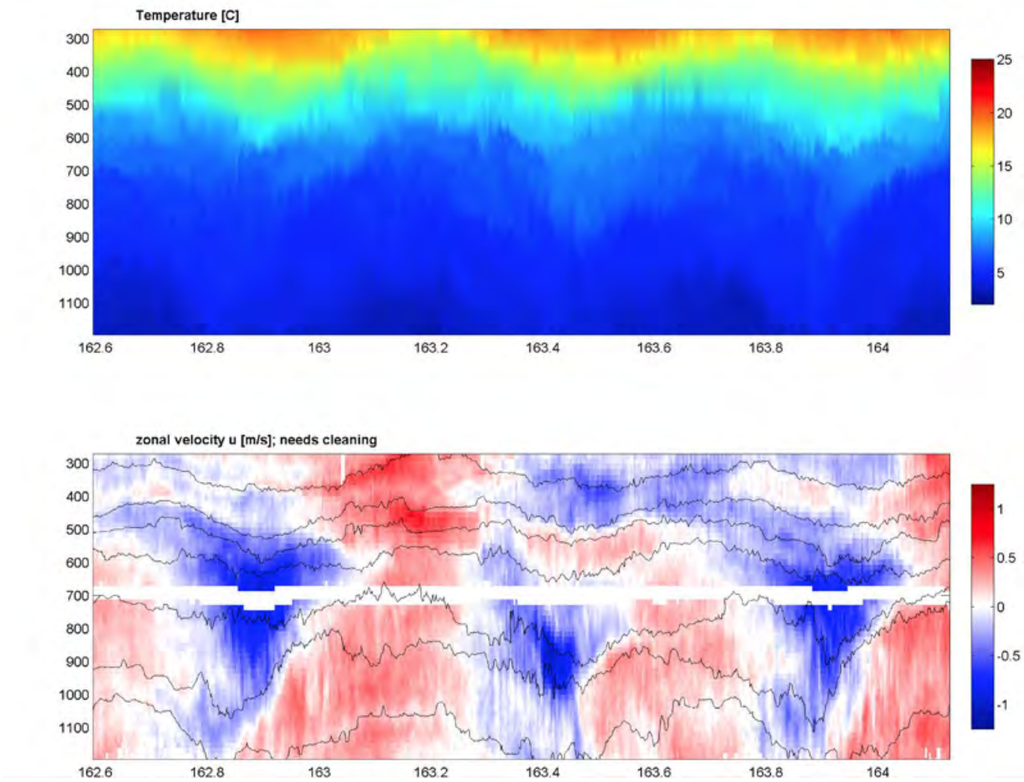


Fig 4: As in Figure 3, except showing an expanded view of a 1.5 day record of the central part of the water column.

RESULTS

All five moorings were deployed in June 2011. The Stablemoor was successfully recovered in Aug from the R/V Revelle, and the remaining 4 T-chains were recovered from the OR1 in Sept. An example of data from the stablemoor is presented in Figuree 3+4; data from the 4 T-chains is presented in Fig. 5.

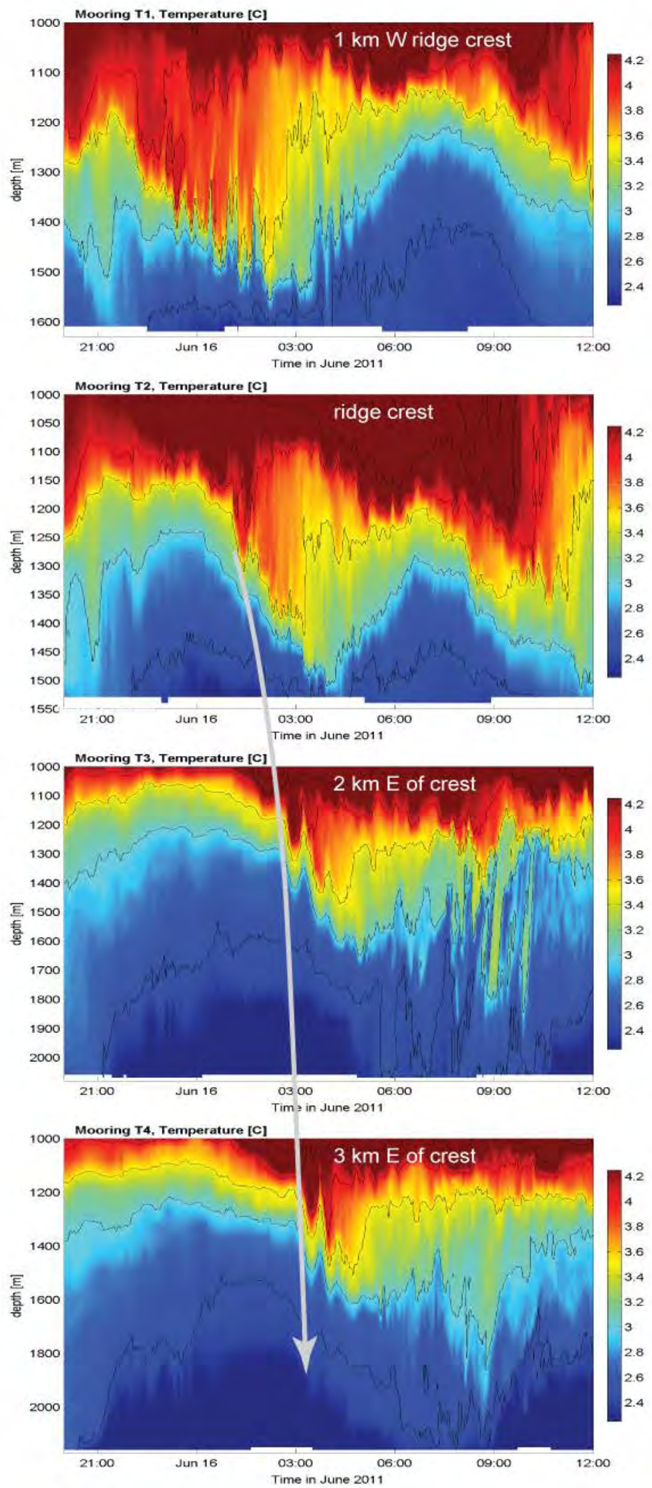


Figure 5: The figure at right shows a 16 h segment of temperature data from the 4 T-chains deployed over the ridge near N2. These moorings were spaced 1 km apart and capture displacements and turbulence in x,z,t space. The depictions at right rival numerical simulations in resolution but capture the represent the true reality and breadth of scales of the real ocean. These figures show the evolution and spatial structure of a 300-m tall wave which grows to 500 m and breaks. Short-wavelength features are coherent across the mooring array and can be tracked (grey arrow). 100-500 m tall turbulent overturns are also visible, particularly at mooring T3 at 0900.

This example represents one 16-h time window within the 3-month deployment. Our objectives are to analyze these records in detail in order to quantify both internal wave and turbulent components. We will combine data from LADCP/χpod, MP-χpods, the moorings shown here, the stablemoor (at A1) and other ancillary moored and model data in these analyses. Ultimately, we will

1. characterize the spatial and temporal variability of high-dissipation events
2. determine the physics of high-wavenumber generation from the surface and internal tides, and the subsequent breakdown into turbulence
3. assess how these dynamics are related to those which have been numerically modeled, with a goal of understanding whether these can be parameterized.

RELATED PROJECTS

Profiling and moored operations are being coordinated with M Alford (UW); analysis of turbulence data are being conducted in conjunction with J MacKinnon (UCSD), H Simmons (UAF) and L. St. Laurent (WHOI). Data/model integration and comparisons will be made with Simmons, Klymak, and Buijsman.

REFERENCES

Klymak, J.M., J.N. Moum, J.D. Nash, E. Kunze, J.B. Girton, G.S. Carter, C.M. Lee, T.B. Sanford, and M.C. Gregg, 2006: An estimate of tidal energy lost to turbulence at the Hawaiian Ridge. *J. Phys. Oceanogr.*, 36, 1148-1164.

Moum, J.N. and J.D. Nash, 2009: Mixing measurements on an equatorial ocean mooring, *J. Atmos. and Oceanic Tech.*, 26, 317-336.

Nash, J.D., E. Kunze, C.M. Lee and T.B. Sanford, 2006: Structure of the baroclinic tide generated at Kaena Ridge, Hawaii, *J. Phys. Oceanogr.*, 36(6), 1123-1135.

PUBLICATIONS

Alford, M.H., J.A. MacKinnon, J.D. Nash, H. Simmons, A. Pickering, J.M. Klymak, R. Pinkel, O. Sun, L. Rainville, R. Musgrave, T. Beitzel, K-H Fu and C-W Lu, 2011: Energy flux and dissipation in Luzon Strait: two tales of two ridges. *J. Phys. Oceanogr.* doi: 10.1175/JPO-D-11-073.1 [published]